Explain why maintaining a resting potential requires ATP.

(3)

An explanation that includes the following points:

- because ATP is used by the sodium-potassium pump (1)

(actively transport)

- to move sodium ions and potassium ions across the cell membrane (1)

- to establish concentration gradients for sodium ions and potassium ions (1)

(b) The types of muscle fibres present in samples taken before the training and after 12 weeks of low and moderate training were determined.

Fibre type	Percentage of fibres (%)		
	Before training	After 12 weeks of training	
		Low	Moderate
Slow twitch	44	44	44
Fast twitch	6	2	1
Intermediate	50	54	55

Intermediate fibres have structural properties between those of slow and fast twitch fibres.

(i) Describe how the structure of an intermediate fibre will differ from the structure of a slow twitch fibre.

A description that includes three of the following points:

- less myoglobin (1)
- fewer mitochondria (1)
- more sarcoplasmic reticulum (1)
- higher glycogen content (1)

(ii) During a seizure, part of the brain will be overactive.

Describe how positron emission tomography (PET) could be used to identify the part of the brain involved.

(3)

A description that includes three of the following points:	
• isotope {that emits positrons / is incorporated into glucose} (1)	Accept suitable named isotope e.g. carbon-11 or oxygen-15, radioactive material in glucose
• more active neurones with increased respiration (1)	
• will require increased supply of glucose (1)	Accept will {absorb/use} more glucose
• positrons (emitted from glucose) produce gamma rays that detected and are converted into an image (1)	

---

5 One cause of blindness is a mutation in the DNA coding for the enzyme RPE65.

The enzyme RPE65 converts trans-retinal to cis-retinal.

(a) Explain why mutations in the RPE65 gene can result in blindness.

(3)

An explanation that includes three of the following points:

- **active site no longer complementary to trans-retinal (1)**
- **cis-retinal cannot be regenerated (1)**
- **therefore, rhodopsin cannot be formed (1)**
- **and rod cells will not have any photoreceptor (1)**

Describe how heart rate is controlled in response to changes in the blood, folfollowing exercise.

A description that includes the following points:	
• cardiovascular control centre in the medulla oblongata (1)	
• detects change in blood pH (following exercise) (1)	Accept increase in lactate / CO_2
• as blood pH increases (more) impulse are sent via the parasympathetic nerve (1)	Accept vagus nerve
• slowing (the rate of impulses from) the SAN (1)	

Describe how a neurotransmitter transmits a nerve impulse across a synapse. (4)

A description that includes four of the following points: • impulse (arriving) at the pre-synaptic knob opens (voltage-gated) calcium ion channels (1) • calcium ions diffuse in and cause vesicles containing neurotransmitter to fuse with the presynaptic membrane (1) • neurotransmitter is released into the synaptic cleft and binds to receptors on postsynaptic membrane (1) • opening (ligand-gated) sodium channels (1) • depolarising the membrane and initiating an action potential (1)

One treatment for Parkinson's disease is a drug called L-DOPA.
Describe how L-DOPA reduces some of the symptoms of Parkinson's disease.
ÿÿÿ

description that includes three of the following points:	
• (in Parkinson's disease) dopamine producing cells in the motor cortex die (1)	ACCEPT in basal ganglia / in midbrain
• L-DOPA crosses the blood brain barrier (1)	
• in the brain L-DOPA is converted to dopamine (1)	
• restoring control of muscle movement (1)	ACCEPT replacing the dopamine lost in the motor cortex

Scientists can induce pluripotent stem cells to produce transcription factors involved in the synthesis of dopamine.
(i) Explain how transcription factors are involved in the synthesis of dopamine.
ÿÿÿ

• (transcription factors) bind to {DNA / genes} involved in the synthesis of dopamine(1)	ACCEPT gene/promotor region of DNA for dopamine
• allowing mRNA synthesis (1)	ACCEPT RNA polymerase binding / forming a transcription initiation complex
• that is translated to produce the enzymes that synthesise dopamine (1)	

(a) Describe the role of calcium ions in producing contraction of a muscle fibre.
ÿÿÿ

• calcium ions bind to troponin (1) • causing tropomyosin to move (1)	ACCEPT change in shape
• allowing the myosin (head) to bind (1)	ACCEPT exposing the myosin binding site / allowing actomyosin bridges to form

(b) The table shows some features of slow and fast twitch muscle fibres.

/britishstude

Feature of fibre	Slow twitch fibre	Fast twitch fibre
Number of mitochondria per fibre	Many	Few
Number of myoglobin molecules per fibre	Many	Few
Capillary network	Larger	Smaller
Contraction	Slow and sustained	Rapid and intense

Olympic marathon runners have a high proportion of slow twitch fibres in their muscles.

Explain how the features of slow twitch fibres, shown in the table, are of benefit to an Olympic marathon runner.

(4)

• many mitochondria allows more (aerobic) respiration(1)	ACCEPT more ATP produced
• many myoglobin molecules allows greater (store)of oxygen (1)	
• larger capillary network ensures good supply of {oxygen/ glucose} (1)	
• slow sustained contraction allows longer periods ofexercise / race for longer(1)	ACCEPT in context endurance events / decrease in {fatigue / tiredness}

https://britishstudentroom-b

2 Vitamin A is an essential component of the human diet.

Rice is a staple food in parts of the world where a lot of people have vitamin A deficiency.

Rice contains no β-carotene or vitamin A.

Cells in the human intestine can convert β-carotene from the diet to vitamin A.

Some soil bacteria can produce large quantities of β-carotene.

(a) Describe how genetic engineering could be used to produce rice that contains β-carotene.

(4)

Answer	Additional guidance
A description that includes four of the following points: • {identify / isolate} gene(s) involved in making beta-carotene in bacteria (1) • cut {DNA sequence / extract (beta carotene) gene}using restriction {endonuclease /enzyme} (1) • insert (beta carotene) gene into vector (1) • method of inserting vector into rice described (1) • grow rice and select for modified rice plants with high yields of beta carotene (1)	ACCEPT obtain gene by reverse transcriptase from mRNA synthesize gene (from a database) ACCEPT gene isolated using restriction enzyme = 2 marks (mp1 and 2) ACCEPT a named vector eg plasmid, liposomes e.g. heat shock, gene gun. micro-injection

(i) Describe the possible risks of growing genetically modified rice plants.

(3)

Answer	Additional guidance	N
A description that includes three of the following points: • accumulation of genetically engineered material in the environment / other species (1) • cross breeding with other species (1) • unknown long term effects of eating GMOs (1) • allows production of superpests (1)	ACCEPT accumulate in non-target organisms altered gene is found in other species ACCEPT pollen transfer to related species, ACCEPT Named symptom e.g. yellowing of skin, joint pain, dizziness, bleeding, beta carotene is a gene inhibitor, ref allergies credit idea of superweeds/superpests	

(ii) Suggest how one of these risks could be reduced.
(1)

accept grow in secure greenhouses, growseparately GM and non GM crops

Describe the difference between a negative feedback mechanism and a positive feedback mechanism. (2)

-positive feedback results in an increase in the change (of the variable)
-negative feedback results in decrease in the change (of the variable)

Explain how small molecules like creatinine are filtered from the blood in the glomerulus. (3)

explanation that includes the following points: • creatinine is a small molecule (1) • therefore can be forced through the {pores / basement membrane} (1) • as a result of high pressure in the glomerulus (1)	ACCEPT ultrafiltration occurs for mp1 / ignore any RMM figures allow through fenestrations

---

Describe how ATP is synthesised by oxidative phosphorylation in the mitochondrion. (3)

A description that includes three of the following points: • reference to chemiosmosis (1) • electrons passed between (electron carriers / electron acceptors) releasing energy (1) • energy used to move protons (out of matrix) into inter membranal space (1) • role of stalked particle in generation of ATP from ADP and Pi (1)	electrons passed along ETC correct reference to ATP synthase in generation of ATP

Describe how ATP is used to supply energy for biological processes.(2)

Question number	Answer	Additional guidance
1(c)	A description that includes two of the following points: • hydrolysis of {ATP / bonds}(1) • releases energy (1)	

Explain how the loop of Henle acts as a countercurrent multiplier to produce concentrated urine. (4)

An explanation that includes four of the following points:

- flow of filtrate in tubules in opposite direction (1)
- because sodium ions actively transported out of the ascending limb (1)
- therefore water out from descending limb (and solutes from ascending limb) (1)
- due to increase in concentration gradient between tubular fluid and interstitial space (1)

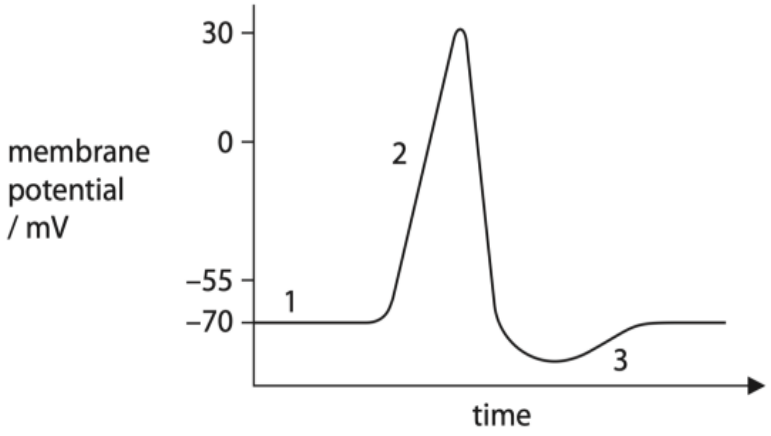
Describe how ADH is involved in the control of the water potential of the blood. (4)

Answer	Additional guidance
A description that includes four of the following points: • water potential of blood monitored by osmoreceptors in hypothalamus (1) • release of ADH from (hypothalamus) pituitary gland (1) • (in blood to kidneys)where ADH acts on {collecting ducts / distal convoluted tubul}) (1) • increase in permeability to water of cell membranes (1) • more water reabsorbed so water potential of blood back to normal range (1)	Accept insertion of aquaporins into cell membranes (of CT and DCT)

(ii) Describe the role of rhodopsin in rodcells. (3)

Question number	Answer	Additional guidance
5(a)(ii)	A description that includes three of the following points: • rhodopsin is the {photoreceptor / photosensitive pigment} (1) • when light absorbed cis retinal (+ opsin) is converted to trans retinal (+ opsin) (1) • causes sodium channels to close (1) • membrane becomes hyperpolarised (1)	accept absorbs light accept Na^+ gated channels blocked

(b) The diagram shows the change in membrane potential as an action potential is transmitted in a motor neurone.



Explain why the membrane potential changes between 1 and 2.

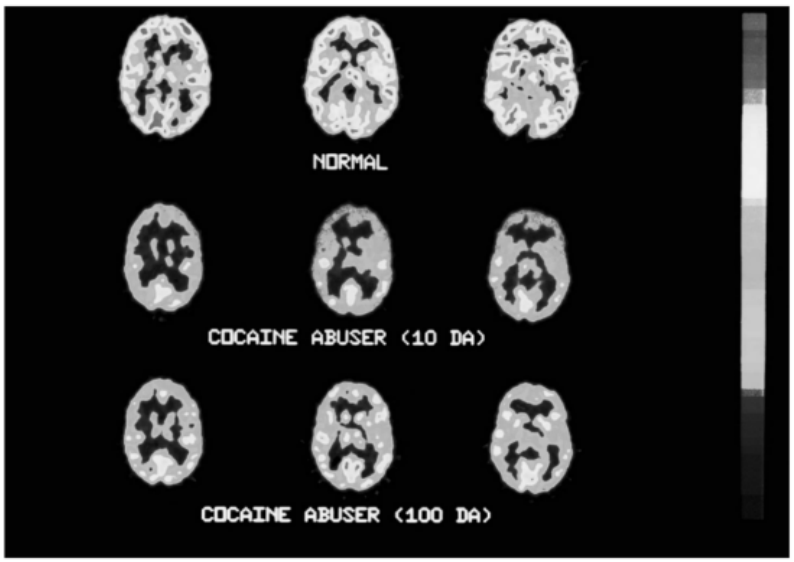
(2)

Answer	Additional guidance
An explanation that includes two of the following points: • stimulus initiates change in (voltage / membrane potential)(1) • sodium ion channels open / sodium ions rush in causing membrane potential to become less negative (1) • if above threshold potential depolarisation initiated (1)	Stimulus cause change resting potential

Explain why the speed of conduction differs in myelinated and nonnonÿmyelinnonÿmyelinatedÿne

Answer	Additional guidance
An explanation that includes three of the following points: • myelin (covers axon) and acts as an insulator (1) • {myelinated fibres have regular gaps / nodes of Ranvie}r along axon where action potential occurs (1) • nerve impulse jumps {from node to node/ in saltatory conduction) (1)	 accept opening of gated channels at nodes of Ranvier where action potential occurs

(d) The positron emission tomography (PET) images show the brain of an individual before (control) and after taking the drug cocaine.

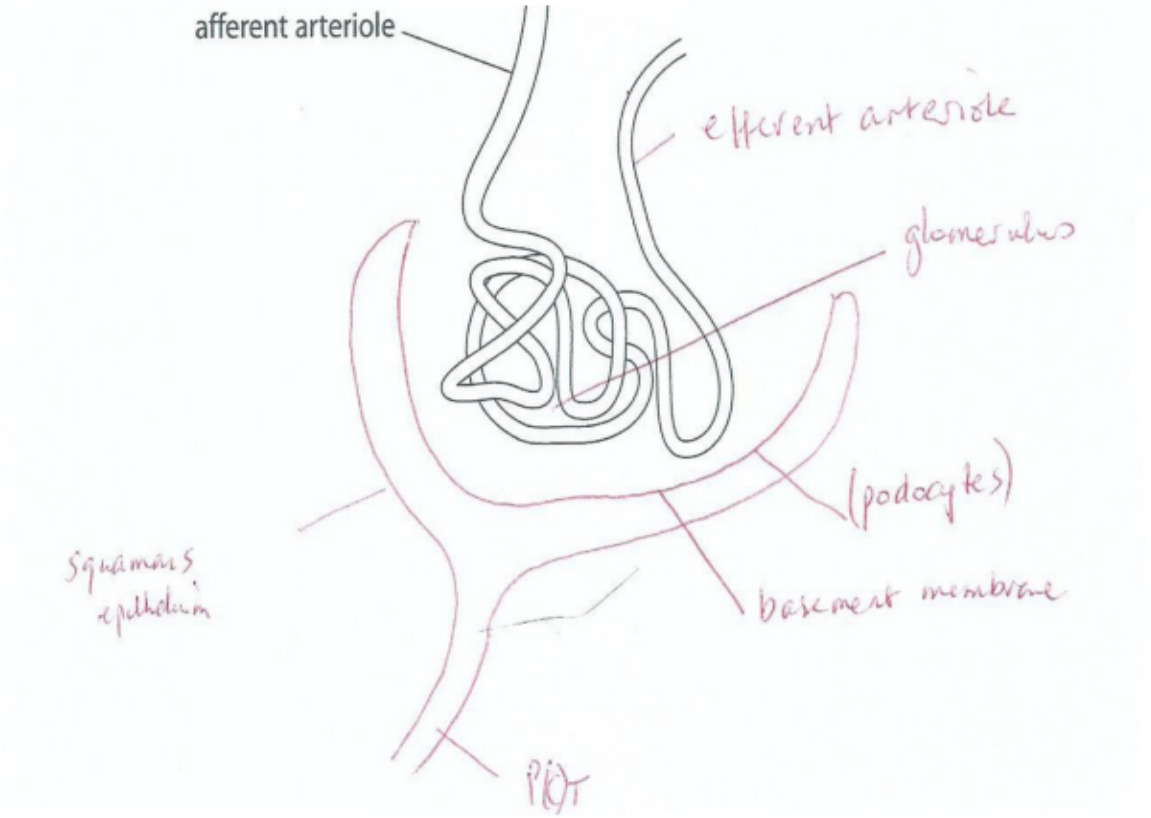


(Source: © BROOKHAVEN NATIONAL LABORATORY / SCIENCE PHOTO LIBRARY)

Explain how positron emission tomography (PET) can be used to identify the change in activity in the brain after taking this drug.

(4)

Question number	Answer	Additional guidance	Mark
6(d)	A description that includes four of the following points: • radioactive tracer added with glucose (and injected into blood stream) (1) • (carried to brain and) taken up by active (respiring) cells (1) • (sensors in)PET scanner detect radioactivity (in different regions of the brain) (1) • build up (2D or 3D) images to show where cells stimulated (by cocaine) are found (1) • the PET shows more regions taking up radio activity in the(cocaine) brain (1)	 accept added to water accept gamma rays	(4)



(3)

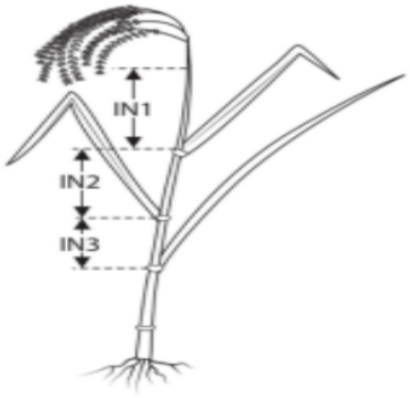
(b) Describe how glucose reabsorption takes place in the nephron.(3)

Answer	Additional guidance	Mark
A description that includes the following points: • occurs in proximal (convoluted) tubule (1) • using {transport molecules / transporters/ active transport} (in the membrane of the nephron) (1) • (co transport) with sodium ions (1) • diffuse into blood (capillaries) {down /along} concentration gradient (1)	ACCEPT channel proteins / carrier proteins ignore ref to sodium pump ACCEPT facilitated diffusion	**(3)**

(b) The effect of a gibberellin on the growth of cereal plants was investigated.

Different concentrations of the gibberellin were sprayed on cereal plants.

The lengths of the first, second and third internodes (IN1, IN2, IN3) were measured, as shown in the diagram.



The table shows the effect of the gibberellin on the mean lengths of the first, second and third internodes.

Concentration of the gibberellin / ppm	Mean length / cm		
	first internode	second internode	third internode
0	36	19	14
10	36	19	14
100	41	21	14
1000	52	22	15
2500	56	22	15

Comment on the effect of the gibberellin on the growth of cereal plants. (2)

Answer	Additional guidance
An answer that includes the following points: • increasing concentration of the gibberellin increases {length / growth} (of all internodes) (1) • increase is mostly in the length of the first internode (1)	 ACCEPT positive correlation ignore gibberellin increases plant growth unqualified ACCEPT {least / smallest} effect on the last/3rd internode

(ii) Suggest how the gibberellin causes this effect.(3)

An answer that includes three of the following points: • gibberellin {enters the nucleus / binds to cell surface receptors} (1) • gibberellin {acts as a transcription factor / activates transcription factor} (1) • effect of transcription factor (1) • (causing) cell elongation / cell division (and causes internode elongation) (1)	 ACCEPT secondary messenger e.g. activates protein synthesis / stimulates amylase production / amylase breaking starch down into glucose for respiration

Parkinson’s disease is caused by a loss of neurones in part of the brain called the substasubstantia
CoCoÿbeneldCoÿbeneldopa is used to treat Parkinso
Co Coÿb Coÿbeneldopa is a mixture Coÿbeneldopa is a mixture of Lÿdopa and a drug t into dinto dopamine in the

(a) Explai (a) Explain why using Co (a) Explain why using Coÿbeneldopa will be m to treat Parkinson’sto treat Parkinson’sÿdisease.
ÿ(3

An explanation that includes three of the following points: • dopamine cannot cross the blood brain barrier (1) • this drug ensures more L-dopa {is present in blood /can cross the brain barrier / reaches the brain} (1) • resulting in (a greater) increase in dopamine levels in the brain (1) • statement about why increased dopamine would help treat Parkinson’s (1)	ACCEPT larger ignore large ACCEPT L-dopa (only) converted to dopamine in the brain e.g. transmission of electrical impulses to post synaptic neurones / increase in motor responses

Compare and contrast the function of a sensory neurone and a motor neurone. (3)

Question number	Answer	Additional guidance	Mark
5(a)(ii)	An answer that includes three of the following points: Similarities • both transmit (electrical) impulses (1) • both may synapse with relay neurones (1) Differences • sensory neurone impulses go towards the {CNS/relay neurone} whereas motor neurone impulses go away from {CNS/relay neurone} (1) • sensory neurones transmit impulses from {receptor /sensory} cells whereas motor neurone transmit impulses to {effector/muscle} cells (1)	do not piece together – has to be in same / adjacent sentences (but not separate paragraphs) do not accept messages / signals for S1, D1 and D2 ACCEPT both release neurotransmitters (in synapse) ignore brain Note: sensory sends impulses from receptor to CNS and motor brings impulse from CNS to effector = both D1 and D2	(3)

(b) In an investigation, tomato plants were genetically modified to convert the amino acid tyrosine into L-dopa.

Three genes were used in this investigation:

- a control gene that is not involved in the production of L-dopa
- MYB12, a plant gene that produces a transcription factor
- CYP76, a gene found in beetroot that codes for an enzyme that converts tyrosine into L-dopa.

The table shows the concentration of L-dopa in the tomato fruit from genetically modified plants.

Genes used to modify the tomato plants	Concentration of L-dopa in the tomato fruit / mg 100 g^{-1}
none	1.2
control gene	1.2
MYB12	1.5
CYP76	10.2
CYP76 and MYB12	14.6

Describe how tomato plants could be genetically modified to make the eenzyme thenzyme that converts tyrosine to

A description that includes the following points:		
• {the gene / CYP76} that converts tyrosine to L dopa is {extracted / isolated} (1)	ACCEPT {isolate / extract / cut out / synthesise} the gene	
• use of same {endonuclease / restriction enzyme} to cut genetic material of plasmid (and isolated gene) (1)		
• method of insertion of vector into a {tomato/host} cell (1)	ACCEPT description of method of insertion e.g. use of {gene gun /heat shock/ liposomes / CRISPR} e.g. infect using {non-lytic virus / Agrobacterium tumefaciens}	**(3)**

(b) Guillain-Barré syndrome is a disorder of the nervous system.

The immune system damages the myelin sheath surrounding the axons of individuals with Guillain-Barré syndrome.

Symptoms of this disorder include:

- inability to maintain steadiness when walking
- inability to feel any sensations in the limbs
- loss of reflexes such as knee jerk.

Suggest why a person with Guillain-Barré syndrome will suffer from the symptoms of this condition.

(3)

Answer	Additional guidance	Mark
An answer that includes three of the following points: • {loss of / no} (insulating) myelin (1) • decreases speed of nerve impulse / depolarisation no longer just occurs at nodes of Ranvier (1) • motor neurones {no longer transmit impulses / impulses are transmitted slower} (causing loss of function in the affected area) (1) • impulses from receptors do not reach CNS / impulses are not transmitted along sensory neurones to CNS (1)	ACCEPT nerve impulses take longer as has to go through all neurone not just nodes of Ranvier ACCEPT saltatory conduction does not occur ignore impulses being lost ACCEPT {fewer/slower} impulses reaching {effector /muscles} (so loss of function) (slower both mp2&3) ACCEPT fewer impulses from receptors reach CNS	**(3)**

ii) Mutations in the genes coding for voltageii) Mutations in the genes coding for voltageÿ neurological conditions.

Explain how th Explain how these mutations might cause these neurological

Answer	Additional guidance	Mai
An explanation that includes four of the following points: • a mutation changes {the base sequence (of this gene) / the amino acid sequence} (of the calcium ion channel protein) (1) • {resulting in a change in shape / prevents the opening} of the calcium ion channel (1) • this stops influx of calcium ions (across presynaptic membrane) (1) • (fewer calcium ions result in) fewer vesicles containing neurotransmitter fusing with presynaptic membrane (1) • fewer {nerve impulses/action potentials} generated at post synaptic {membrane / neurone} (1)	ACCEPT stops calcium ions passing through {membrane / ion channel} ACCEPT prevents release of neurotransmitter /less neurotransmitter will be released (into synapse) ACCEPT less depolarisation of post synaptic {membrane / neurone}	**(4**

Explain the difference in the number of mitochondria between fast twitch and slow twitch muscle fibres. (3)

Answer	Additional guidance	Mark
An explanation that includes the following points: • slow twitch muscle fibres have more mitochondria (than fast twitch muscle fibres) (1) • because they rely on (ATP from) aerobic respiration (1) • (slow twitch fibres have more mitochondria) because oxygen supply is sufficient / more capillaries carrying oxygenated blood / cells contain (more) myoglobin (1)	ACCEPT converse ACCEPT fast twitch relies on (ATP from) {anaerobic respiration / creatine phosphate} ACCEPT converse	**(3)**

Describe the rolDescribe the role of ATP in muscle

Answer	Additional guidance	Mark
A description that includes the following points: • ATP binds to the myosin head (1) • {releasing the myosin head from the actin strand/breaking the cross-bridge} (1) • ATP is hydrolysed (by the myosin head) (1) • providing energy to move the myosin head {back/upright} (1)	ACCEPT ATP broken down into ADP ACCEPT change shape of myosin head / return to original position Do not accept the power stroke	**(4)**

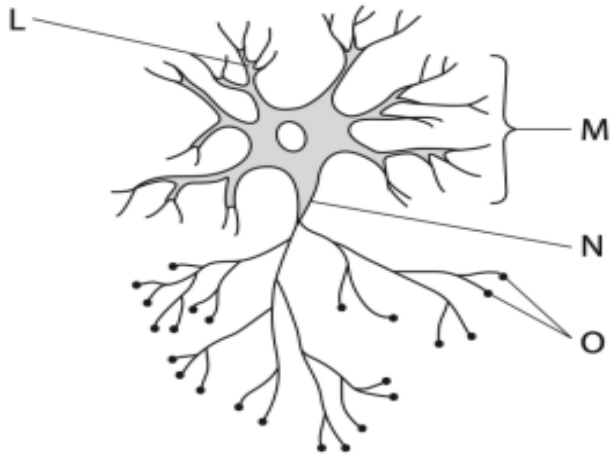
Describe how chemiosmosis is involved in the synthesis of ATP. (2)

Answer	Additional guidance	Mar
A description that includes two of the following points: • accept explanation of how proton gradient set up (1)	can piece together reference to movement of electrons along electron carriers releasing energy to {pump protons into intermembrane space / create electrochemical gradient}	Exp (2)
• {protons / hydrogen ions} move through {membrane protein/ protein channel /ATP synthase/ ATPase} (1)	accept protons move down electrochemical gradient	
• {conversion of ADP + Pi to ATP / phosphorylation of ADP} (1)	accept ADP + Pi -> ATP	

Describe the role of ATP in the sliding filament theory of muscle contraction. (3)

A description that includes three of the following points:	mps need to be in logical order to gain credit	Ex
• ATP binds to the myosin head (1)		(3)
• {releasing the myosin head from the actin strand/breaking the cross-bridge} (1)		
• ATP is hydrolysed (1)	ACCEPT ATP broken down into ADP and Pi	
• (providing energy) to change the myosin head {shape / position}(1)	Do not accept the power stroke	
• allowing myosin to bind to actin / form actin-myosin cross bridge (1)		

3 The diagram shows a relay neurone.



(a) (i) Complete the table by filling in the names of each labelled part.

(2)

Label	Part
L	dendrites
M	cell body / centron
N	axon
O	(pre)synaptic {endings /knob/bulb}

Explain why a myelinated neurone conducts an impulse faster than a non-myelinated neurone of the same diameter. (3)

Answer	Additional guidance
An explanation that includes three of the following points • myelin (sheath) acts as an insulator (1) • gaps (in myelin sheath) are called nodes of Ranvier /nodes of Ranvier have higher number of (voltage gated) sodium channels (1) • {action potentials/depolarization} can only occur at nodes on Ranvier (in myelinated neurones)(1) • (therefore) impulse jumps from one node of Ranvier to the next(1)	accept {action potentials / depolarization}occur along the whole unmyelinated neurone mp4 accept converse accept reference to saltatory conduction

The heart rate for a cheetah increases from 120 bpm to 250 bpm during a chase. It can reach speeds of 100 km hr–1.

(i) Explain how the heart rate of a cheetah can be increased during a chase.(4)

An explanation that includes the following points:	Do **not** accept reference to signals / messages	Expert
• chemoreceptors detect {lower pH of blood / increased blood CO_2 concentration}/ baroreceptors detect change in blood pressure (1)	increased adrenaline production	**(4)**
• (electrical) {impulses sent to medulla (oblongata)/cardiovascular control centre (CVC)} / chemoreceptors are located in medulla oblongata (1)	adrenaline which circulates in the blood	
• impulses travel {from the medulla oblongata / via sympathetic nervous system} to the SAN /more impulses sent to {AVN/ bundle of His / Purkyne fibres} (1)	mp3 adrenaline binds to receptors in {heart muscle / SAN}	
• (causing SAN) to increase frequency of depolarisation causing an increase in {heart rate / systole} (1)	mp4 (causing SAN) to increase frequency of depolarisation causing an increase in {heart rate / systole}	
	chemoreceptors in medulla oblongata detect increase in blood CO_2 = 2 marks	

ii) Suggest why a cheetah can maintain this heart rate and speed for only a short period of time.(2)

Answer	**Additional guidance**	**Mar**
An answer that includes two of the following points:		Exp
• fast twitch muscles fatigue quickly / are for short distance (sprinting) /cheetah cannot get oxygen fast enough for aerobic respiration (1)	the sprint requires large amounts of ATP (for muscle contraction)	**(2)**
• (cells / muscles) respire by anaerobic respiration (1)		
• (therefore) build up of {lactic acid / oxygen debt} (from anaerobic respiration) (1)	accept lactate accept release of heat so body temperature goes up rapidly / homeostatic mechanisms cannot occur quick enough	

The kaThe kangaroo rat's kidneys play an important role in the process of conserving
Explain how the nephrons (kidney tubules) in the kidneys of the kangaroo rat are able to produce very concentrated urine. (2)

Answer	Additional guidance	Mark
An answer that includes two of the following points: • (nephron has) long(er) loop of Henle (1) • higher concentration of ions in the medulla (1) • (kidneys/tubule/ DCT and collecting duct/ loop of Henle}) reabsorb {large quantities of / more } water (1)	accept reference to counter current multiplier accept ADH results in increased absorption of water accept increased permeability to water in DCT and collecting duct accept ADH causes insertion of {water channels / aquaporins} in DCT and collecting duct	Expert (2)

6 Plants respond to external stimuli.

(a) Phytochrome molecules are found in plants.

Phytochrome exists in two forms, Pr (P_{660}) and Pfr (P_{730}).

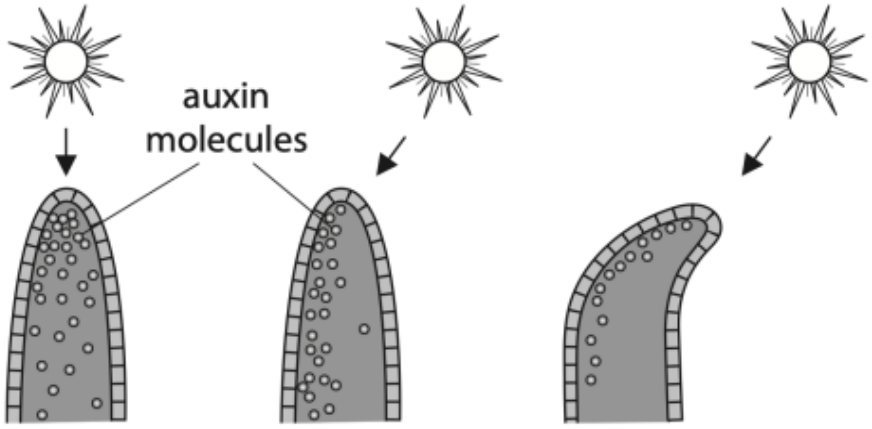
Which row shows the action of these two forms of phytochrome?

(1)

		Absorbs far red light	Breaks down in the dark
☒	**A**	Pfr	Pfr
☐	**B**	Pfr	Pr
☐	**C**	Pr	Pfr
☐	**D**	Pr	Pr

(b) Auxins (IAA) are plant growth substances.

The diagram shows auxin molecules producing a phototropic response in a shoot.



Explain the role of auxins in this phototropic response.

Use the information in the diagram to support your answer.

(3)

Answer	Additional guidance
An explanation that includes three of the following points:	
• auxin accumulates on shaded side (of the tip/stem/shoot/plant) (1)	accept accumulates on the left of diagram
• {stimulating/causing} cell elongation (1)	accept auxins move away from the exposed light
• detail of mechanism of action of auxin (1)	e.g. auxins stimulate the transport of Hydrogen ions into the cell wall or decrease pH activating {cell wall proteins / enzymes / chemicals /expansins} / {altering the hydrogen bonding within / decreasing strength of} the cell wall allowing elongation when water taken in / ref to activation of transcription factors
• causing the plant to grow towards {light / sun} (1)	accept causing positive phototropism do not accept bend towards light

(c) Seeds contain starch. This starch is used to supply energy when the seed germinates.

Gibberellins are a group of naturally occurring plant growth substances.

Gibberellins regulate starch hydrolysis in the seed.

Explain how gibberellins can produce this effect on the seed.

(4)

Answer	Additional guidance
An explanation that includes four of the following points:	ignore amylose
• (gibberellin) binds to receptor / carrier molecule in the cell / acts as a transcription factor(1)	
• (amylase) {transcription factor/gene is activated} (1)	transcription factor binding to promotor region of gene cause the inactivation of (amylase) gene {inhibitor protein/repressor molecule}
• allowing {(amylase gene) transcription / production of (amylase) mRNA / translation mRNA / production of amylase} (1)	
• amylase (hydrolyses/ converts) starch into {maltose / glucose} (1)	ignore monomers activates gene that produces amylase = mps 2 and 3

Animals and plants can be genetically modified.

(a) Recombinant human erythropoietin (rHE) is a protein drug that can be given to patients with low haemoglobin concentrations.

(i) Sheep have been genetically modified to produce rHE in their milk.

Explain how a sheep could be genetically modified to produce rHE in its milk.

(4)

Answer	Additional guidance
A description that includes four of the following points: • {identify/isolate/ cut out} the (human) rHE gene (1) • Cut {DNA sequence / gene} using restriction {endonuclease / enzyme} (1) • insert the gene into a vector (1) • inserting vector into suitable target (sheep) {cell / tissue} (1)	gene coding for rHE is isolated using restriction enzymes = 2 marks accept named vector e.g. plasmid, virus ignore bacteria e.g. udder cells / milk (protein) producing cells /fertilized sheep egg cell / embryo /zygote

(ii) Some patients receiving rHE develop anti-rHE antibodies.

Describe how these antibodies may be produced. (4)

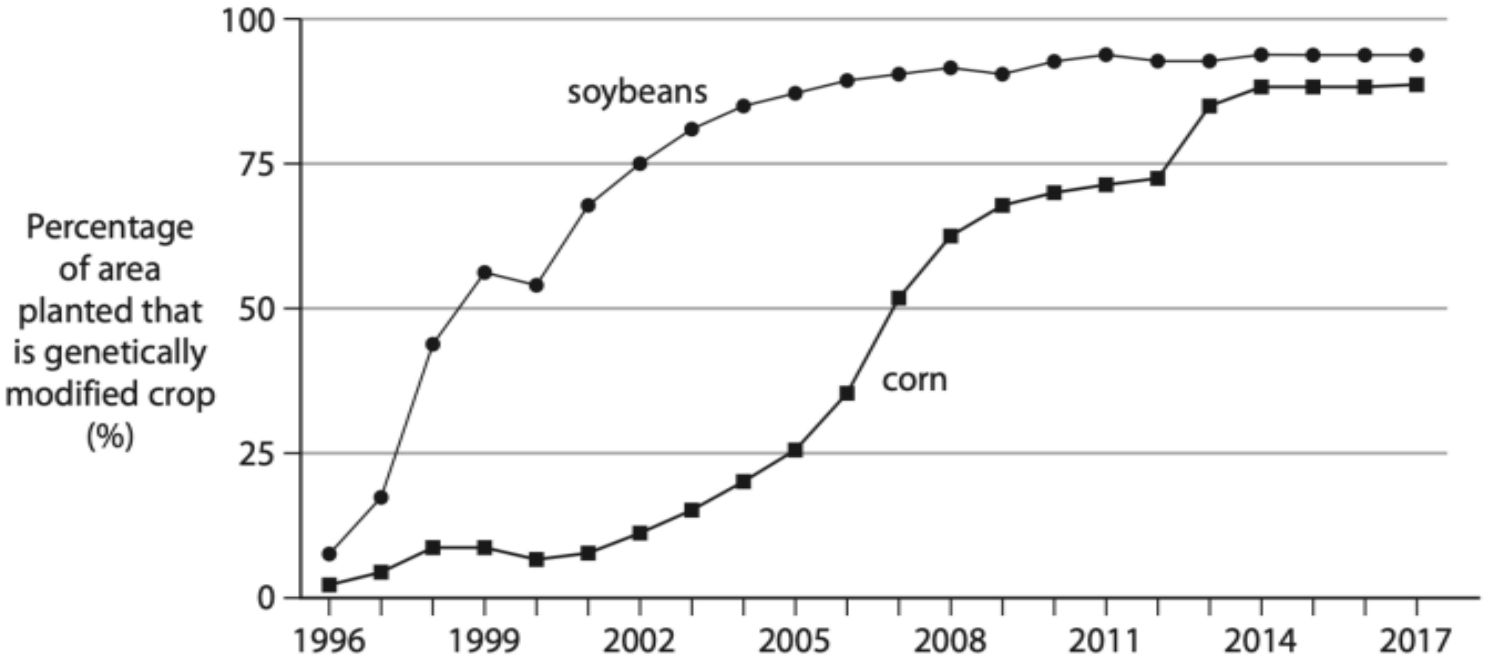
Answer	Additional guidance
A description that includes four of the following points: • rHE acts as an antigen (1) • {(phagocyte /macrophage / APC} presents antigen to (B/T) lymphocyte (1) • T helper cells activate the B cells (1) • differentiate into plasma cells (1) • plasma cells {release/ produce} (anti-rHE) antibodies (1)	accept antigen recognized as foreign accept B cells present antigen to themselves. accept T helper cells cause the production / formation of B effector cells and B memory cells

*(b) Advances in genetic engineering have allowed for precise control of the genetic changes introduced into plants.

The table describes some examples of the use of genetic modification in plants.

Trait	Plant	Details
herbicide tolerance	soybean	glycophosphate herbicide tolerance using a gene from the bacterium *A. tumefaciens*
insect resistance	corn	resistance to European corn borer using a gene from *B. thuringiensis*

The graph shows the increase in the use of genetically modified crops in the United States from 1996 to 2017.



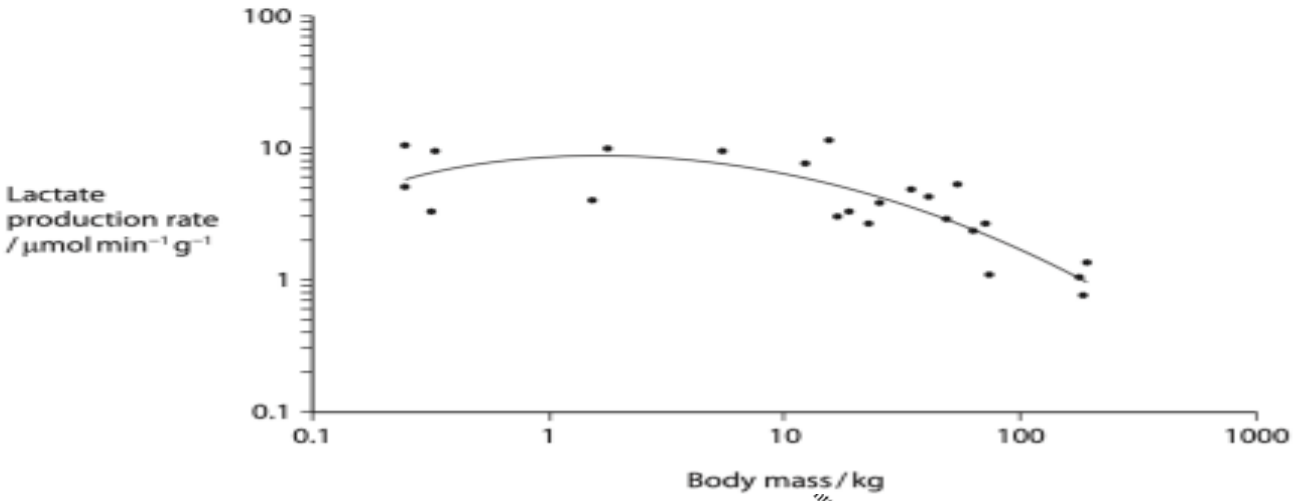
Discuss the risks and benefits of genetic modification in valuable agriculturalÿplants.
Use all the data and your own knowledge to support your answer. (6)

Answer Additional guidance
An answer that includes the following points: **Indicative content** - description from graphs and experimental data • (many) crops have been engineered to provide resistance to pests or herbicides eg. soybean, corn • soybean will not be killed by (glycophosphate) herbicides • corn will not be eaten by the core borer • ---------- • herbicide tolerant soybean went from 7% of planted area in 1996 to 95% in 2017 • insect resistant corn went from 6% in 1996 to 88% in 2017 • increase in planting of both GM soybean and GM corn • more GM soybean planted (than GM corn) • general increase in production of genetically modified crops ---------- **explanation of benefits** • higher yields / less damage by pests • more appealing colour / useful feature • GE foods having longer shelf life • more predictable food supplies for ever growing population ---------- • improved nutritional content • 'medication' provided through GE foods • can help prevent {malnutrition / disease} ---------- • (reduced use / cost) of herbicides and pesticides • withstand environmental conditions ---------- **discussion of risks** • increasing demand agricultural resources and land • reducing land available to grow other crops ---------- • increasing monoculture • declining biodiversity / stated effect on (stated local ecosystem) ---------- • unknown consequences of foreign gene expression / long term effect unknown • horizontal gene transfer to other organisms and species eg antibiotic resistance, weeds becoming herbicide

(Source: © Danny Ye/Shutterstock)

An investigation measured the lactate production rate of these crocodiles when they were active.

The graph shows the results of this investigation.



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Each plotted point on the graph represents a single crocodile.

Discuss the roles of the different types of respiration in these active crocodiles.

Use the information in the graph and your own knowledge to support your answer.

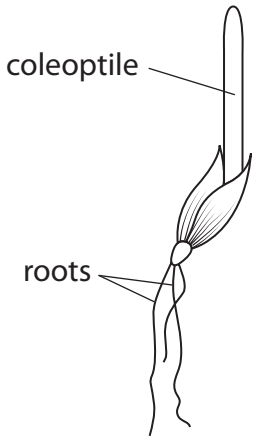
(6)

Question number	Answer
5(c)	An answer that includes the following points: **Indicative content** • No direct relationship between body mass and lactate production • The larger the size of the crocodile the lower the rate of lactate production • Highest rate of lactate production in 20kg crocodiles • Smallest crocodiles have same rate of lactate production as 50kg crocodiles • Comment on the link between aerobic and anaerobic respiration **Description of named responses** • As crocodiles were exercising vigorously the aerobic pathway cannot keep up. • ATP generated anaerobically in glycolysis using glycogen stores in the muscle. • Energy used to allow the crocodile to move very rapidly, if only for a short time. **Chemical nature of responses** • I mol of glucose from glycogen generates 3 mols of ATP and 2 mols of lactate • Detailed description of anaerobic pathway in glycolysis • Detailed description of aerobic pathways **Detailed mechanism of responses** Level 1: Description of (a minimum of 2 specific) results from experimental data. Level 2: All of level 1 plus reference to chemical nature of anaerobic or aerobic respiration Level 3: All of level 2 plus detailed mechanism for anaerobic and aerobic respiration

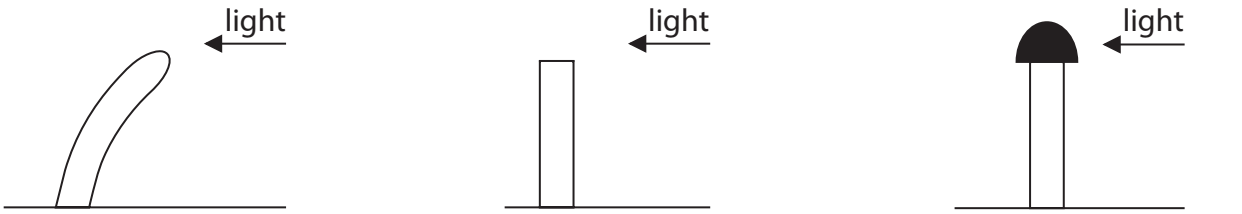
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

*(b) The drawing shows the results of some experiments investigating phototropisms.

The diagram shows a coleoptile of a seedling.



Experiment 1:

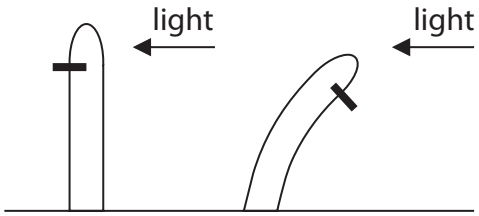


intact coleoptile illuminated from one side

tip of coleoptile removed and remaining coleoptile illuminated from one side

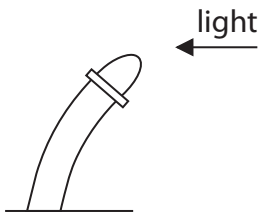
black cap placed on tip of coleoptile and coleoptile illuminated from one side

Experiment 2a:



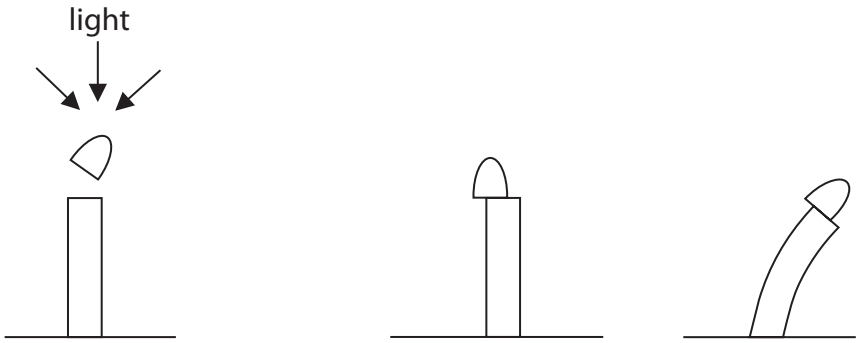
plastic sheet inserted below the tip of the coleoptile and the coleoptile illuminated from one side

Experiment 2b:



gel layer placed below the tip of the coleoptile and the coleoptile illuminated from one side

Experiment 3:



coleoptile illuminated and the tip removed

tip replaced on one side of the remaining coleoptile that is then kept in the dark

*

An answer that includes the following points: Indicative content – description from experimental data
experiment 2 shows that substance responsible for phototropism passes through gel but not plastic experiment 1 shows that cause of phototropism is chemical in nature and is produced in the tip experiment 3 chemical substance can diffuse and cause curvature even in the dark

-Chemical nature of responses
phototropism caused by auxins receptor proteins (phototropins) activate several hormones including auxin Auxin transported down dark side and less on bright side Auxin stimulates elongation on shaded side to give curvature

-Detailed mechanism of responses
Auxin stimulates decrease in cell pH which activates enzymes responsible for cell growth and elongation Auxin affects hydrogen ion pumps (proton pumps) Auxin causes intracellular reserves of hydrogen ions to increase which lowers the pH on dark side lower pH activate enzymes these disrupt hydrogen cross links in cell wall increased osmotic gradient due to movement of solutes water enters cell (and increased turgor pressure) leads to swelling of cell

Level 1: Discuss some of the results from experimental data.

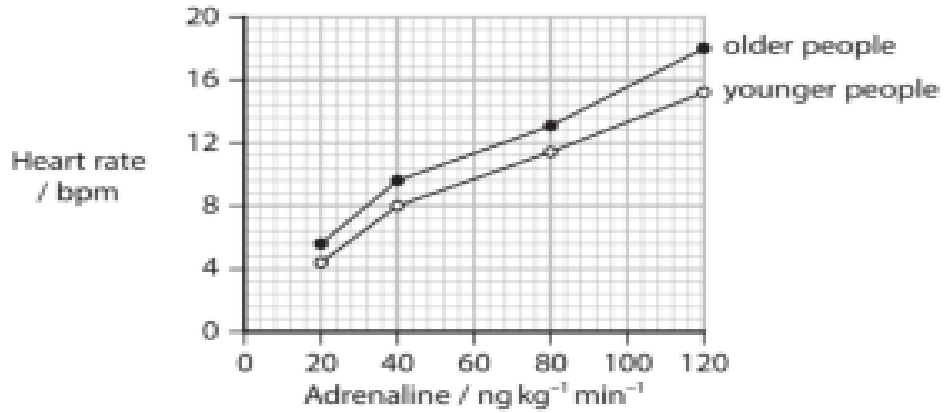
Level 2: Discuss all of level 1 plus reference to specific chemical nature of phototropism

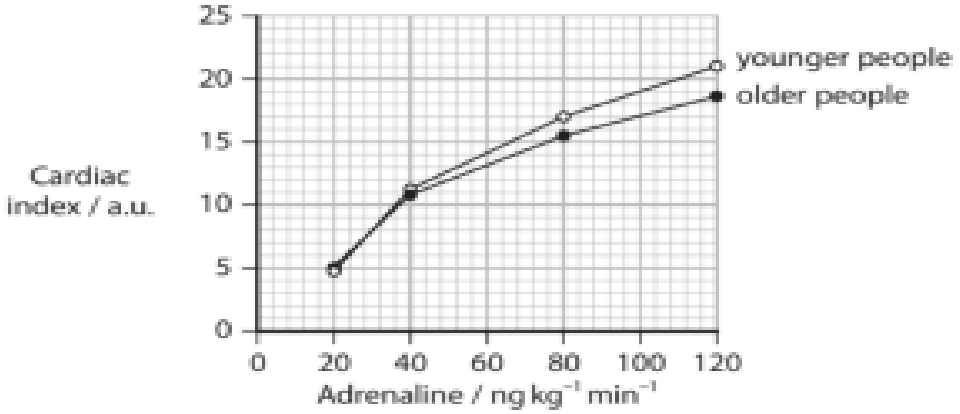
Level 3: Discuss all of level 2 plus detailed mechanism for phototropism at molecular level

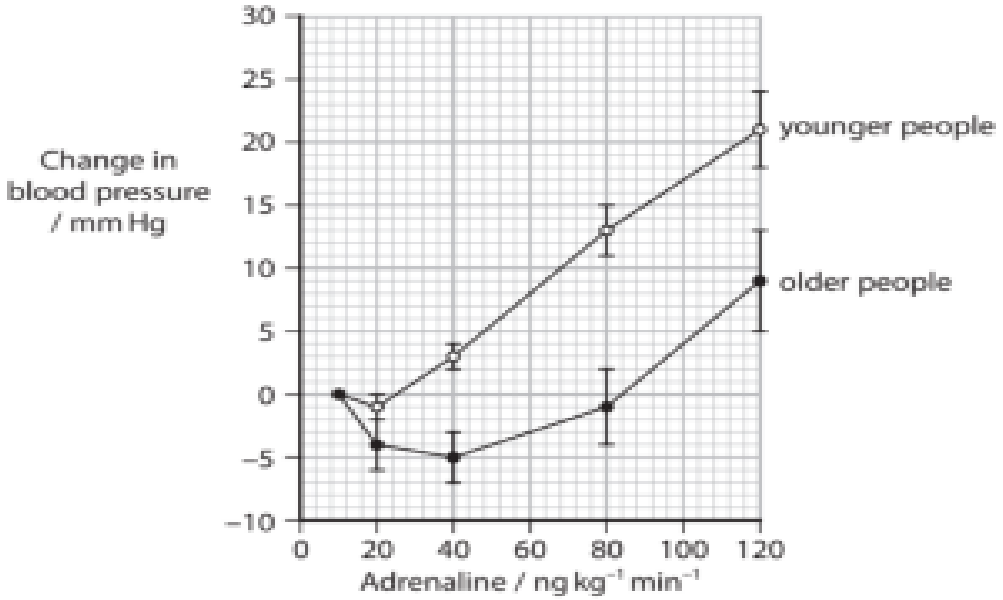
*(iii) Ageing is associated with changes in the way the heart responds to adrenaline.

In an investigation, the effects of adrenaline on the hearts of young people and old people were recorded.

The graphs show the results of this investigation.







Discuss the effect of ageing on the response of the heart toÿadrenaline. Use the information in the graphs to support your answer. (6)

6(b)(iii) *	An answer that includes the following points: **Indicative content** - description from graphs and experimental data **Heart rate:** • as the concentration of adrenaline increases, the increase in heart rate increases in both groups • this increase is (slightly) {greater in the older group of people / lower in younger people} • at all concentrations of adrenaline the older group have greater {change/heart rate} / at all concentrations of adrenaline the younger group have smaller {change/heart rate} --- • but there are no error bars to judge whether or not this difference is significant • due to stated effect of aging on heart - weaker muscle/effect on SAN/lower stroke volume **Cardiac index:** • as the concentration of adrenaline increases, the increase in cardiac index increases in both groups • the increase is the same at {20 / 40} ng kg^{-1} min^{-1} • at concentrations above 40 ng kg^{-1} min^{-1} the increase is {lower in older people / greater in younger people} • overall the increase cardiac index is {lower for the older people / greater for younger people} --- • due to lower cardiac output / increased body surface area/lower stroke volume / (accept converse for younger people) • but there are no error bars to judge whether or not this difference is significant	**(6)**

Change in blood pressure

- blood pressures decrease and then increase in both groups (as adrenaline concentration increases)
- a concentration of 20 ng kg^{-1} min^{-1} decreases the blood pressure in both groups
- a concentration of **{84-120} ng kg^{-1} min^{-1}** increases the blood pressure in older people
- in older people lower change in blood pressure (in response to higher concentrations of adrenaline) / converse for younger people

---

- due to stated changes of aging on heart muscle/ blood vessels/baroreceptors
- no overlap of error bars between older and younger people indicate that these differences are significant (at all concentrations of adrenaline) / the error bars overlap for some concentrations for older people meaning that these differences are not significant / the error bars do not overlap for some concentrations for younger people meaning that these differences are significant

Level 1:

1 or 2 graphs commented on changes in heart rate/cardiac index/blood pressure as concentration of adrenalin increases

Level 2:

2 or 3 graphs commented on, including details of the effect of adrenaline on older people

Level 3:

All 3 graphs commented on, including details of the effect of adrenaline on older people and discussion of the significance of the data.

Describe how light is detected by the rod cells in the eye .(4)

Answer	Additional guidance
An explanation that includes four of the following points: • rhodopsin (in rod cells) absorb light and {splits into retinal and opsin / becomes bleached}(1) • cis-retinal converted to trans-retinal(1) • sodium ion channels (in surface membrane) close (1) • {rod cell / membrane} becomes hyperpolarised (1) • no glutamate transmitter {released/produced} (into synaptic cleft) (1)	accept rhodopsin absorbs light and forms opsin /light hits rhodopsin and bleaches it accept membrane permeability to sodium ions decreases do not accept (opsin) blocks Na^+ channel

Suggest how the genes expressed in a sensory neurone could be identified. (3)

Answer	Additional guidance
An answer that includes three of the following points: • extraction of mRNA (1) • use of (specific) microarray (1) • use of fluorescent {dyes /marker/ probe}(1) • (comparing stimulated and un-stimulated neurones) {use of bioinformatics/ algorithms to analyse data} (1) OR • extraction of mRNA(1) • use of reverse transcriptase to form cDNA(1) • use of PCR(1) • use of gel electrophoresis and compare banding(1)	Do not pick and mix accept reference to samples of mRNA [ignore marker gene]

Explain how mechanical stimuli, e.g. pressure, are converted into electrical signals in cells. (3)

Answer	Additional guidance
A explanation that includes three of the following points: • {mechanical stimulus / pressure} changes shape of the membrane (1) • causes {ion channel / protein} to {change shape /activated/ open} (1) • allowing influx of (sodium / calcium) ions (1) • initiates {depolarization/ action potential} (1)	accept stretches membrane ignore potassium ions

Describe how the autonomic nervous system regulates the breathing rate when a person isperson isÿre

Answer	Additional guidance
A description that includes four of the following points: • Chemoreceptors detect {pH of blood / blood CO_2 concentration} (1) • send (fewer) impulses to the {respiratory centre / ventilation centre / medulla} (1) • decreased frequency of impulses to {intercostal muscles/diaphragm} (1) • allowing (breathing muscles) to {relax / contract less frequently} (1) • rate set by the {respiratory centre / ventilation centre / medulla / pons} (1) **OR** • As air enters the lungs, stretch receptors in the lungs are activated (1) • Send impulses to inhibit inspiratory centre (1) • (resulting in) {no/fewer} impulses to {intercostal muscles/diaphragm} (1) • allowing (breathing muscles) to {relax / contract less frequently} (1) • rate set by the {inspiratory centre / expiratory centre / medulla / pons} (1)	Do not accept message / signal ACCEPT impulses sent via parasympathetic nervous system ignore ventilation centre

Explain how neurones can respond to different neurotransmitter substances. (3)

Answer	Additional guidance
An explanation that includes three of the following points:	
• receptors on post-synaptic membrane (1)	ACCEPT {ion channel / gates} on post-synaptic membrane
• (receptors) have (different) three-dimensional shapes/ are specific for (different) neurotransmitters (1)	ACCEPT (receptors have) complementary shape to specific neurotransmitter
• description of response once the neurotransmitter has bound to the receptor (1)	e.g. opening of sodium channels / causing an action potential / depolarising membrane / inhibitory neurotransmitter prevents {depolarisation /action potential}

Suggest how the activity of the sympathetic nervous system in immune organs could regulate inflammation (2)

Answer	Additional guidance
An answer that includes two of the following points:	
• release neurotransmitters (1)	ACCEPT release of named neurotransmitter e.g. noradrenaline / adrenaline / epinephrine / acetylcholine ignore release of chemicals
• that act on white blood cells / (stimulate) {spleen/thymus/lymph nodes} (1)	
• to {release (more/ less) cytokines / release white blood cells into blood / recruit white blood cells from blood} (1)	ACCEPT release (more/ less) of named chemical e.g. histamine

Explain how reflex circuits in the gut cause a bolus to move. (4)

Answer	Additional guidance
An explanation that includes four of the following points:	
• bolus acts as a stimulus/ receptor detects bolus (1)	ACCEPT description of food stretching gut wall
• motor neurone transmits (electrical) impulse to (smooth) muscle (1)	
• detail of how nerve impulse stimulates muscle contraction (1)	ACCEPT release of neurotransmitter
• therefore {circular muscle contracts / longitudinal muscles relax} {around/above} bolus (1)	ACCEPT {circular muscle contracts / longitudinal muscles relax} in {propulsive / proximal} segment
• therefore {circular muscle relax / longitudinal muscles constrict} in {front/below} of bolus (1)	ACCEPT {circular muscle relax / longitudinal muscles constrict} in receiving segment

Explain how the interaction of microbial and other factors could result in gastrointestinal inflammation. (3)

Answer	Additional guidance
An explanation that includes three of the following points:	
• environmental factor changes conditions in the gut / causes a change in the gut flora (1)	ACCEPT new microorganism / pathogen / microbe / bacteria
• therefore microbial {chemicals/toxins} released (1)	
• (chemicals / toxins / microbes) stimulate an {inflammatory response / immune response} (1)	ACCEPT release of {histamine / cytokines}
• explanation of how the inflammatory response occurs (1)	e.g effect of histamine such as vasodilation / oedema occurs / recruitment of inflammatory cells / recruitment of white blood cells